

FIG. 3 shows the X-ray diffraction data for an atomized powder of the present invention.

FIG. 4 shows a plot of hardness vs. nitrogen content of the alloys of the present invention.

FIG. 5 shows a plot of yield strength vs. nitrogen content of the alloys of the present invention.

FIG. 6 shows polarization current vs. the potential for the alloys prepared in the Examples.

#### DETAILED DESCRIPTION OF THE INVENTION

The inventors of the present invention have discovered that a stainless steel alloy having the composition stated above can be formed using a nitrogen gas atomization process followed by consolidation. This particular stainless steel alloy is less likely to form detrimental stable nitrides, such as  $\text{Cr}_2\text{N}$ , and sigma ( $\sigma$ ) phases. In fact, the alloys prepared in accordance with this invention contained no stable nitride or sigma ( $\sigma$ ) phases.

In addition, it has been discovered that the high nitrogen stainless steel of the present invention is very strong, hard, ductile and corrosion resistant. As with all high nitrogen stainless steels, the stainless steel alloy of the present invention has a high work hardening coefficient. The hardness of the alloy of the present invention can be increased by cold work.

As is discussed above, prior art methods are able to produce stainless steel alloys without stable nitride and sigma phases using gas atomization and consolidation via a hot isostatic press, however, the prior art methods require additional processing of the stainless steel alloy after consolidation to eliminate the stable nitride and sigma ( $\sigma$ ) phases. The additional processing of the stainless steel alloy after consolidation with a hot isostatic press involves solution treating and water quenching of the stainless steel alloy. Using the process of the present invention to form a stainless steel alloy having the foregoing described composition, an alloy can be prepared without the need to eliminate stable nitride and sigma ( $\sigma$ ) phases by further processing the alloy after consolidation. This results in a drastic reduction in the processing costs and the ability to form thicker sections of stainless steel alloy.

In the methods of the prior art, the cross-sectional thickness of a section of the stainless steel alloy is limited by the quench sensitivity of the alloys. That is, if the alloy has a cross-section thickness such that the ability to rapidly cool the interior portions of the specimen is limited, the quenching step of the further processing can not rapidly cool the entire portion of the alloy. This results in the reformation of the stable nitride and sigma ( $\sigma$ ) phases in the alloy. Therefore, the cross-sectional thickness of the alloys formed by the prior art is limited by the ability to quench the entire thickness of the alloy.

In the inventive stainless steel alloy of the present invention, formation of the stable nitride and sigma ( $\sigma$ ) phases is less likely to occur. This allows the fabrication of thicker alloy cross-sections because the alloy is less quench sensitive. Generally, there is less likelihood that the alloy has to be solution treated and quenched to remove any nitride and sigma ( $\sigma$ ) phases from the microstructure. Of course, the

alloys of the present invention may optionally be solution treated and quenched.

In the prior art methods, solution treatment and quenching is effected to eliminate the nitride and sigma ( $\sigma$ ) phases, however, a duplex matrix is still another source of concern. In a duplex matrix, a ferrite phase is formed in addition to the austenite phase. A ferrite phase can cleave and fail catastrophically. A ferrite phase also reduces the corrosion resistance in the ferrite crystal structure having much lower nitrogen solubility than the FCC  $\gamma$ -phase.

Forming a stainless steel alloy with a composition of the present invention avoids these problems in the prior art. A goal set forth by the present inventors of the present invention was to form an alloy having substantially a gamma ( $\gamma$ ) microstructure. The alloys of the present invention have a gamma ( $\gamma$ ) microstructure in an amount of at least 99% by volume.

The high nitrogen stainless steel alloy produced in accordance with present invention has high hardness, high strength, high ductility and high corrosion resistance. Typically, the alloys of the present invention have a hardness greater than about 275 ( $\text{HV}_{1000}$ ), a yield strength greater than 590 MPa, an ultimate tensile strength of at least 1000 MPa, a notch impact strength of at least about 100 J, and an elongation of at least 50%.

In the present invention, controlling the amounts of each of the metal constituents of the stainless steel alloy is important. It has been discovered that by controlling the amount of each of the metal components and nitrogen within the following parameters, an alloy can be formed which has substantially a gamma ( $\gamma$ ) microstructure, which is less likely to have stable nitride and sigma phases and has excellent physical properties, including high hardness, high strength, high ductility and corrosion resistance, and phase stability.

Chromium (Cr) content has been set in the range of about 27% to about 30% by weight of the alloy. Preferably, the Cr mass fraction should be between 27.4% and 29.9% by weight. The presence of Cr in this amount ensures that the resulting alloy will have a relatively high nitrogen content. The more Cr present in the alloy, the higher the nitrogen solubility.

Molybdenum (Mo) content has been set at about 1.5 to about 4.0% by weight of the composition. Preferably, the Mo content should be between 1.5 and 3.0% by weight and more preferably between 1.7% and 2.3% by weight and most preferably at or about 2.0% by weight, for example, 1.9 to 2.05% by weight. This amount of Mo helps improve the corrosion properties. Greater amounts of Mo should not be used since Mo is relatively expensive and Mo tends to form an intermetallic sigma ( $\sigma$ ) phase.

Manganese (Mn) is present in the stainless steel alloy and should be limited to about 15%, i.e., less than or equal to 15% by weight. Mn increases the solubility of nitrogen in the alloy, however, Mn has a detrimental effect on the corrosion properties of the resulting alloy. Preferably, the mass fraction of Mn should not exceed 10% by weight. However, this parameter can be relaxed so that the resulting alloy will have the minimum nitrogen content of 0.8%. Most preferably, the alloy of the present invention should contain between about 6.0% and about 15% by weight Mn.